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FINAL REPORT

ON DEVELOPMENT OF

TRANSISTORIZED SYSTEM 1 EQUIPMENT

February 1958

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1. Introduction

a. General

(1) This report describes a transistorized information amplifier, its power supply, the tests performed on these units, and the results of these tests.

(2) See figure 1. The information amplifier, referred to in this report as a C5 unit, consists of a video-amplifier input section (Q1401, Q1402, Q1403, Q1404) followed by a video amplifier channel (Q1406, Q1407, Q1408, Q1409) and an audio amplifier (Q1413). The video channel contains compressor circuits to increase the input dynamic range. The video channel is terminated in pulse-stretcher circuits (CR1411, Q1411, Q1412) which convert narrow input pulses into a form suitable for magnetic-tape recording in the audio-frequency band. The pulse-stretcher output and audio amplifier output are mixed together at the emitter-follower output stage (Q1414) of the C5 unit.

(3) The power supply, referred to in this report as a C6 unit, consists of a square-wave oscillator (Q1601, Q1602, T1601) to convert d-c input power to a-c power, a transformer (T1601) to supply necessary output voltages, and rectifier circuits. The 28-volt input is regulated to 21.5 volts by silicon reference diodes (CR1606, CR1607, CR1608) and an emitter-follower (Q1604). Power-supply outputs are +250 volts at 25 ma, +15 volts at 5 ma, and -27 volts at 100 ma. The -27 volt supply is regulated against load variations by an emitter-follower (Q1603) referenced to -27 volts by silicon diodes (CR1601, CR1602, CR1609). The +15-volt supply is obtained directly from the 28-volt line through filter circuits and a regulator (CR1603, CR1604).

(4) The paragraphs which follow contain test specifications, a description of test methods, tabulated test data for the amplifiers and power supply, and a discussion of test results. Graphical test data, production-test procedures, and sample production-test forms are appended to this report.

b. Specifications

(1) C5 Unit. Electrical specifications for the C5 unit were first presented in Engineering Specification No. 250. These specifications were slightly modified and presented in Specification for AN/ASQ-33 (XH-1). The latter specifications are summarized below.

(a) Input Amplifier Section:

Frequency response shall be substantially uniform in the range from 50 cps to 4 mc, down no more than 3 db at 50 cps and 4 mc.

(b) Video Signal Path:

(1) Frequency response shall be flat within ± 3 db from 40 kc to 2 mc.

(2) Amplification of 0.25 microsecond pulses shall be down no more than 3 db with respect to amplification of 1 microsecond pulses.

(3) Time constant of pulse stretcher shall be such that peak amplitude of stretched pulses will be down no more than 3 db at pulse rates as high as 5 kc.

(c) Audio Signal Path:

Frequency response shall be flat within ± 2 db from 50 cps to 4 kc, down no less than 10 db at 10 kc.

(d) Gain:

(1) Over-all midband video gain (40 kc to 4 mc) shall be no less than 70 db at low input levels.

(2) Over-all midband audio gain (50 cps to 4 kc) shall be no less than 70 db at low input levels.

(3) Amplitude control shall provide ± 10 db control of amplifier output voltage.

(e) Dynamic Range:

Useful r-f dynamic range shall be no less than 35 db.

(f) Tangential Sensitivity:

Tangential sensitivity shall be no less than -45 dbm as measured with modulated r-f signal generator and specified crystal detector.

(2) C6 Unit. Power-supply specifications are tabulated below.

(a) Input Voltage: 24-32V (28V nominal)

(b) Input Current: 0.65A max.

(c) Output Requirements: +250V at 25 ma
+15V at 5 ma
-27V at 100 ma

(d) Regulation: +250V, ± 10% from zero to rated load and over specified range of input voltages

+15V and -27V, ± 2% from zero to rated load and over specified range of input voltages

(e) Ripple Voltage: -27 volts - 0.05 volts peak-to-peak max.
+15 volts - 0.05 volts peak-to-peak max.
+250 volts - 0.10 volts peak-to-peak max.

c. Test Methods

(1) Test instruments and test procedures were substantially the same as those indicated in the appended production-test documents: "TEST PROCEDURE C5 UNIT", and "TEST PROCEDURE C6 UNIT".

(2) For this report, somewhat more detailed results were obtained than are normally required for production testing. In addition, dynamic-range measurements were made using an r-f generator and crystal detector, and the units were subjected to altitude, vibration, and ambient-temperature environmental tests.

(3) In all gain and response measurements involving the application of signals to the C5 unit's input terminals, a 1000-ohm source impedance was used to simulate the impedance of a biased crystal detector.

2. Test Results

a. Tabulated Data, C5 Units

(1) Power Requirements

Serial No. 120	Serial No. 116
0.038 A. at -27V dc	0.038 A. at -27 V dc
0.00057 A. at 15 V dc	0.00058 A. at 15V dc

(2) Gain

(a) Video Gain

	Serial No. 120	Serial No. 116
Maximum insertion gain[1]	73 db	75 db
Normal insertion gain[1]	60 db	60 db
Maximum voltage gain	87 db	86 db
Normal voltage gain	74 db	71 db

(b) Audio Gain

	Serial No. 120	Serial No. 116
Maximum insertion gain[1]	76 db	75 db
Normal insertion gain[1]	60 db	60 db
Minimum insertion gain[1]	45 db	45 db

(3) Tangential Sensitivity

Serial No. 120	Serial No. 116
4 μv at input without crystal	4 μv at input without crystal

1 Insertion gain measured from 1000-ohm source to high impedance load (100K or greater).

(4) Video Input vs Output

(a) p.w. = 1 μs, prf = 1 kc, video gain normal, audio gain minimum. (0 db is tangential-sensitivity level.)

Input Level	Output Level Serial No. 120	Output Level Serial No. 116
0 db	0 db	0 db
+10	+10	+10
15	15	15
20	19	20
25	23	25
30	27	30
35	31	33.5
40	33.5	36.5
50	39.5	39
60	44	42
70	48	45
80	50.5 (7.5V)	46.5 (5.0V)

(b) Variable pulse width, prf = 1 kc, video gain normal, audio gain minimum. (0 db is tangential-sensitivity level.)

Input Level	Pulse Width	Output Level Serial No. 120	Output Level Serial No. 116
0 db	1 μs	0 db	0 db
	0.5	-1	-1
	0.25	-4	-4
	0.20	-8	-6
+5 db	1 μs	+5	+5
	0.5	4	4
	0.25	2	2
	0.20	0	1
+ 10 db	1 μs	+9	+10
	0.5	9	10
	0.25	7	9
	0.20	6	7
	0.15	5	6
	0.1	3	2

Input Level	Pulse Width	Output Level Serial No. 120	Output Level Serial No. 116
+20 db	1 μs	+19 db	+20 db
	0.5	19	20
	0.25	18	19
	0.1	11	14
+30 db	1 μs	+27 db	+30 db
	0.5	27	30
	0.25	26	29
	0.1	20	24
	0.05	16	17
+50 db	1 μs	+39.5 db	+39 db
	0.5	39.5	39
	0.25	39.5	38.5
	0.1	32.5	34
	0.05	23.5	---

(c) Variable pulse width, pulse rate, and audio gain. Video gain normal. (0 db is tangential-sensitivity level.)

Input Level	P.R.F.	Pulse Width	Serial No. 120 Audio Gain 45 db	Serial No. 120 Audio Gain 60 db	Serial No. 116 Audio Gain 45 db	Serial No. 116 Audio Gain 60 db
+10 db	1 kc	1 μs	+10db	10	10	10
		3	10	10	10	10
		10	10	10.5	10	10.5
	2.5	1	10	10	10	10
		3	10	10	10	10
		10	10	10.5	10	10.5
	5	1	10	10	10	10
		3	10	10	10	10
		10	10	10.5	10	10.5
+20	1	1	19	19	20	20
		3	19	19	20	20
		10	20	20	20.5	21
	2.5	1	19	19	20	20
		3	19	19	20	20
		10	20	20	21	21
	5	1	18.5	18.5	19.5	19.5
		3	18.5	18.5	19.5	19.5
		10	19	19	20	20

Input Level	P.R.F.	Pulse Width	Output Level Serial No. 120 Audio Gain 45 db	Serial No. 120 Audio Gain 60 db	Serial No. 116 Audio Gain 45 db	Serial No. 116 Audio Gain 60 db
+40 db	1 kc	1 µs	+33.5 db	33.5	36.5	36.5
		3	33.5	34	36.5	36.5
		10	34.5	35	37	37.5
	2.5	1	34	33.5	36.5	36.5
		3	34	34	36.5	37
		10	35	35	37	38
	5	1	31.5	31.5	34.5	34.5
		3	31.5	32	34.5	35.5
		10	33.5	33.5	35	37
+60	1	1	44	44	42	42
		3	44	44.5	42	43
		10	45	47	43	46
	2.5	1	44	44	42	42
		3	44	44.5	42	43.5
		10	45	48	44	48
	5	1	42	42	39.5	40.5
		3	42	43	39.5	42.5
		10	44	47	41	47

(5) R-F Input vs Video Output

H.P. 614A signal generator, 2000 mc, modulated by 1 µs pulses at 1 kc prf, 1N32R crystal, 20 µA bias, video gain and audio gain normal.

Input Level (dbm)	Output Level (db above tangential) Serial No. 120	Serial No. 116
-55 (tangential sensitivity)	0 db	0 db
-50	8	9.5
-45	18	20
-40	27.5	30
-35	34	36
-30	40	39
-25	45	42
-20	49.5	46
-15	51.5	47.5
-10	52	48

(6) Frequency Response

(a) Audio Response

Audio gain and video gain normal.

Frequency	Output (0 db = 0.5 V rms.) Serial No. 120	Serial No. 116
20 cps	-2 db	-3 db
50	0	0
100	0	0
500	-0.5	-0.5
1 kc	0	0
2	0	-0.5
3	-0.7	-1.5
4 kc	-1.5	-2.5
5	-2	-3.5
7	-3.5	-5
10	-6	-7
20 kc	-14	-15

(b) Video response at output of 4th stage (collector of Q4).

Frequency	Output (0 db = output at 100 kc, approximately 0.1 V pk) Serial No. 120	Serial No. 116
100 kc	0	0
500	0	0
1 mc	0	0
2	0	0
3	-1.5	-3
4	-4	-9
5 mc	-10	---

(c) Video response at output of 8th stage (collector of Q9).

Frequency	Output (0 db = output at 100 kc, approximately 0.1 V pk) Serial No. 120	Serial No. 116
20 kc	-15	-13.5
40	- 5	- 5
50	- 2	- 4
100	0	0
500	0	0
1 mc	0	0
2	- 0.5	0
3	- 8	- 3
4	-15	- 9

b. Tabulated Data, C6 Unit (Serial No. 109)

(1) Regulation vs Output Load

Input = 28.0 volts dc

Percent of Rated Load	-27V Output		+15V Output		+250V Output	
	Volts	Percent Above Normal	Volts	Percent Above Normal	Volts	Percent Above Normal
0	-27.7	0.72	14.5	3.57	262	4.7
50	-27.6	0.36	14.3	2.14	256.5	2.7
100	-27.5	0	14.0	0	250	0

(2) Regulation vs Input Voltage

Output loads: +250V supply = 10K
-27V supply = 270 ohms
+15V supply = 3K

Input	Output					
Volts	Volts	Percent Deviation	Volts	Percent Deviation	Volts	Percent Deviation
+24	+246	-1.6	+13.7	-2.15	-27.3	-0.73
+28	+250	0	+14.0	0	-27.5	0
+32	+254	+1.6	+14.3	+2.15	-27.7	+0.73

c. Environmental Test Data

(1) Temperature Tests at Sea Level Pressure

(a) Video Insertion Gain, C5 Units. p. w. = 1 μs prf = 1 kc. Audio and video gain at normal settings.

Temp. (C^o)	Serial No. 120 Input +10 db Above Tangential	Serial No. 120 Input +20 db Above Tangential	Serial No. 116 Input +10 db Above Tangential	Serial No. 116 Input +20 db Above Tangential
-55	55 db	59.5 db	59 db	62 db
-45	58	59.5	-	-
-42	-	-	61	62
0	60	59.5	-	-
+20	-	-	60	60
+24	60	59.5	-	-
+40	60	59.5	60	60
+65	58.5	58	58	58.5

(b) Audio Insertion Gain, C5 Units. Frequency = 1 kc at 1 V rms output level. Audio and video gain at normal settings

Temp. (C^o)	Serial No. 120	Serial No. 116
-55	58 db	60 db
-45	-	-
-42	59	59.5
+20	60	-
+24	-	60
+40	60	60
+65	60	60

(c) Pulse Response, C5 Units. prf = 1 kc. Video gain = 60 db. Audio gain = 45 db

Input pulse width for which output is down 3 db (referred to output for 1 μsec pulse).

	Serial No. 120		Serial No. 116	
Temp. (C^o)	Input Level +10 db Above Tangential	Input Level +20 db Above Tangential	Input Level +10 db Above Tangential	Input Level +20 db Above Tangential
-55	0.27μs	0.25μs	0.2μs	0.2μs
-45	0.25	0.23	-	-
-42	-	-	0.19	0.18
+20	-	-	0.21	0.18
+24	0.23	0.20	-	-
+40	0.23	0.20	0.22	0.18
+60	0.25	0.25	0.25	0.18

(d) Output Voltages, C6 Unit (Serial No. 109)

Input voltage = 28.0 volts

Output load: +250 V supply = 10K
- 27 V supply = 270 ohms

	Output Voltage	
Temp. (C^o)	+250V Output	-27V Output
-55	+245	-26
-40	248	-26.5
-27	250	-26.9
0	250	-27.2
+25	250	-27.5
+50	253	-28
+62	257	-28.7

(2) Vibration Tests

(a) Two C5 Units (Serial Nos. 124 and 130) and a C6 Unit (Serial No. 114) were installed in a mounting base (Serial No. 113) and the complete modular assembly was attached to a vibration table. One microsecond pulses, at a pulse rate of 1 kc, were applied to the input of each C5 unit at a level which produced a peak output of approximately 5 volts. The output signals were monitored with an oscilloscope. The 250-volt output of the C6 unit was loaded with 10,000 ohms and the voltage metered during tests.

(b) The operating equipment was vibrated in a horizontal plane at frequencies from 5 to 500 cps and 0.01 inch total amplitude, or ± 2g applied acceleration, whichever was least. The frequency was varied continuously from 5 to 500 cps over a period of 30 minutes, and this cycle was repeated three more times for a total of 120 minutes. The frequencies of all natural resonant points were noted.

(c) The operating equipment was vibrated in the same direction as above for 10 minutes at the principal resonant frequency and with ± 2g applied acceleration.

(d) Steps (b) and (c) were repeated in the horizontal plane with direction changed 90°.

(e) Steps (b) and (c) were repeated in the vertical direction.

(f) Acceleration of the equipment at the strongest resonant points was measured with an accelerometer mounted on the left C5 unit (Serial No. 130). Readings were as follows.

Axis	Resonant Frequency	Accelerometer Reading
Vertical	135	20.5g
Lateral	95	27.5
Longitudinal	160	21.7

(g) No structure or component failures were observed after completion of tests. No variations in output-signal amplitude, waveshape, or in power-supply voltage were observed during the 6.5-hour test period.

(3) Altitude Tests

The C5 units, C6 unit, and mounting base used in the vibration tests were operated at 70,000 foot pressure and 25° C. ambient temperature for one hour. The signal input and power supply load conditions and monitoring facilities were the same as during the vibration tests. No variations were noted during the test.

d. Discussion of Results

(1) Gain

(a) All frequency-response and dynamic-range characteristics were measured using a 1000-ohm generator, a source impedance simulating the characteristics of the biased crystal that will provide input to the C5 unit in system applications. Using a 1000-ohm source impedance, insertion gain measurements yield values 15 to 20 db lower than the actual voltage gain of the amplifier. However, the insertion-gain method is more representative of amplifier performance under actual operating conditions because the amplifier input impedance varies from unit to unit and is considerably lower than the crystal impedance.

(b) The maximum voltage gains of units 120 and 116 are 7 db and 6 db higher than required by the specification. The normal gain is obtained by adjusting the video gain control for 60 db insertion gain with a video input signal 10 db above tangential level. This adjustment provides maximum output voltage consistent with full dynamic range of the amplifier. The normal voltage gains are 1 to 4 db higher than the nominal gain required by the specification. Gain may be reduced up to 20 db without affecting the signal-to-noise ratio of the C5 unit. Increasing gain more than 3 to 6 db above normal will reduce the dynamic range.

(c) The gain adjustment provided in the C5 unit differs from the specification in that separate controls are used in the audio and video signal paths. Range greater than that specified is available in each of the controls, the audio range being 30 db and the video range infinite. Normally the audio insertion (or voltage) gain will be set equal to the video gain.

(2) Tangential Sensitivity

(a) Measurements using a pulse-generator source indicate that tangential sensitivity at the input of the amplifier is less than 5 microvolts. Additional tests indicate that amplifier output noise increases approximately 2 db when a biased crystal (1N32R or 1N23DR, -20μA bias) is substituted for the 1000-ohm resistive source. Therefore, the equivalent input noise due to the first transistor is equal to or slightly greater than crystal noise. The best obtainable sensitivity using an r-f signal and crystal detector at 2000 mc was -55 dbm.

(b) It should not be concluded that mismatch between crystal impedance and amplifier input impedance has a significant effect on r-f sensitivity. Amplifier input impedance is reduced by a series feedback circuit. The feedback circuit proportionally reduces noise generated by the first transistor in the feedback loop. Therefore, amplifier gain compensates for the mismatch loss without substantially affecting the relationship between detector and amplifier noise sources.

(3) Dynamic Range

(a) Figure 2 of the appended graphical data shows output vs input amplitude relations for pulse signals. The relationship is nearly linear from 0 db to 20 db above tangential sensitivity. As input amplitude is increased from + 30 db to + 80 db, the compression characteristic of the amplifier becomes pronounced, and output amplitude rises from + 27 db to only + 50 db. For input levels over + 80 db, the amplifier stage ahead of the video gain control is saturated. Stages following the gain control saturate at a C5-unit output level of approximately 10 volts. By means of the video gain control, the gain of the C5 unit may be increased 3 to 6 db so that saturation of all video stages occurs at the same input level. This adjustment does not affect the dynamic range.

(b) The compression characteristics of the two units differ slightly because of differences in compressor-diode characteristics and differences in gain of the compressor-amplifier sections. For this reason, it will probably be necessary to provide a calibration curve similar to those of figure 2, with each production amplifier.

(c) Data contained in paragraph a(4) of Section 2 indicates the output vs input characteristics of the C5 unit under conditions of varying pulse widths and pulse repetition frequencies. At high signal levels, response is satisfactory for input pulses shorter than 0.15 microseconds. At all signal levels greater than 10 db above tangential, response is satisfactory for input pulses shorter than 0.25 microseconds. At the tangential level, response is down 4 db for 0.25 microsecond input pulses. These data are shown graphically in figure 3.

(d) For low-level input signals whose pulse width is greater than 0.3 to 0.5 microseconds, the output level is substantially independent of pulse width. However, for high-level input signals, audio-channel amplification of low-frequency pulse components causes the output level to increase slightly at greater pulse widths. This effect is minor for pulse repetition frequencies below 1 kc, but becomes progressively more pronounced as the repetition rate is increased to 5 kc. Figures 4 and 5 show the relationship between output level and pulse width at 1 kc, and 5 kc under conditions of minimum and normal audio gain. With normal audio gain, amplification of low-frequency components is much more pronounced. This effect results partly from the gain of the video path being reduced by high-amplitude signals, while the gain of the audio path remains unchanged. Amplification through the audio path has little effect upon pulses whose amplitudes are less than 40 db above tangential level.

(e) For low-level pulse signals the output of the C5 unit is constant for varying pulse repetition rates up to 5 kc. At higher signal levels, the output drops with increasing repetition rates, at maximum input level being down 2 to 3 db at 5 kc.

(f) Figure 6 shows the relationship between output pulse amplitude and the level of pulse-modulated r-f signals applied to a crystal detector. The test conditions are indicated in the tabulated data of Section 2, paragraph a(5). At higher levels the square-law characteristics are seen to be overcompensated by amplifier compression. The r-f dynamic range for both units is greater than 40 db.

(4) Frequency Response

(a) Frequency response from 50 cps to 4 mc was measured at the output of the input-amplifier (collector of Q4) at low levels. The response of the input amplifier departs from the specification at high frequencies since it is down more than 3 db at 4 mc. However, high-frequency response of the over-all video channel was well within the specification limit, the drop at 2 mc being less than 3 db for each of the units.

(b) The video-channel frequency response is shown graphically in figure 7. Frequency response of the video channel was measured from 20 kc to 4 mc at low levels. Low-frequency response of the video channel showed a minor departure from the specification, being down 5 db at 40 kc rather than 3 db. This would affect pulse performance of the amplifier to a small extent only for slow rising input pulses (rise time 10 microseconds or greater).

(c) The audio-channel frequency response is shown graphically in figure 7. At high frequencies, audio-channel response departs slightly from the specification, being down 6 and 7 db rather than 10 db at 10 kc. To meet the requirement of a 10-db drop at 10 kc, an additional R-C cutoff section would be required, but adding to circuit complexity for the purpose of reducing the response at 10 kc is probably undesirable.

(5) Power Supply Performance

(a) Regulation characteristics of the C6 unit are shown graphically in figure 8. Characteristics are within specification over the full range of load and power-source variations. Variations of the -27V supply which will have greater effect on performance of the C5 units, are held within 0.75% from 0 to full load (output impedance less than 2 ohms) and to $\pm$0.5% for $\pm$14% power-source variation.

(b) The output voltage variations are primarily due to changes in reference voltage of the regulator diodes under varying current conditions.

(6) Environmental Tests

(a) Figure 9 indicates the variation in video and audio gains of the C5 units over the ambient temperature range of -55° C. to +65° C. and at two different pulse input levels. It is shown that variations are held within $\pm$1 db from -40° C. to +60° C. and within $\pm$2 db from -55° C. to +65° C., except for the low-level video gain of Serial No. 120 which dropped 2 db at -45° C. and 5 db at -55° C.

(b) Loss in video gain at the upper temperature limit is principally affected by two phenomena:

(1) For higher signal levels, the compressor diodes in the video amplifier stages (CR1414, etc.) have increased forward conductance at high temperature and cause increased compression.

(2) For lower signal levels, reverse resistance of the first stretcher diode (CR1411) is reduced at high temperatures and decreases the stretched pulse width applied to the stretcher amplifier (Q1411).

(c) Loss in video gain at low temperatures is caused by decreased transistor gain.

(d) An additional effect, not noted in the data, is an increase in output noise level at high temperatures due to an increase in transistor noise. The maximum observed increase was 6 db at $+65^{\circ}$ C. This would decrease tangential sensitivity by about 3 db (r-f power). Crystal detector noise characteristics, however, are similar and will contribute equally to the increase of noise at high temperatures, so that degradation of sensitivity caused by the C5 unit alone will add only 1 to 2 db to that caused by the crystal detector.

(e) In figure 10, the variation in sensitivity with respect to pulse width over the ambient temperature range is shown to be small. In the worst case, the input pulse for 3 db loss at the C5 output (referred to the output for 1-microsecond pulses) rises from 0.23 microsecond at $+25^{\circ}$ C. to 0.28 microsecond at -55° C. with +10 db input level.

(f) Environmental temperature effects in the C6 unit (shown in figure 11) are caused mainly by change in regulator-diode characteristics. For the -27V supply,

the change in output voltage is aggravated by change in output transistor (Q1603) gain, causing decreased loading on the regulator diodes at low temperatures. The sensitivity to load variations, although not shown for the -27V supply, is also dependent on transistor gain. The output impedance of the -27V supply increases to about 4 ohms at low temperatures and drops to about 1 ohm at high temperatures. Data is not shown on the +15V supply because its output voltage is almost entirely dependent on well-known characteristics of regulator diode.

(g) Results of the vibration and altitude tests, which are indicated in the tabulated data section, show no adverse effects.

e. Performance of Units in Mounting Base

(1) The two C5 units were installed in the mounting base and operated with the C6 power supply as a modular unit. Performance was satisfactory in all respects. A magnetic shield surrounding the power supply is required to isolate the magnetic field of the power transformer from the amplifier circuits of the C5 units.

(2) A possible difficulty is seen in system operation because of multiple circuit grounding. The 28-volt d-c primary-power source is connected to the vehicle frame, and since the negative side of the 28-volt source is connected to the power-supply common through the +15-volt supply, a chassis ground exists at the power supply. Circuit ground is isolated from the chassis at all other points in the amplifier circuits, including the signal-input connectors. However, connection of the antennas establishes a second chassis ground point at the crystal holders, forming a ground loop that may be particularly susceptible to pickup from the power transformer.

Insulation of the crystal holders from their mounting frames appears to be the most expedient solution.

(3) Peak noise voltage caused by power-supply ripple at the outputs of both C5 units was less than 4 db above peak amplifier noise when the amplifier inputs were terminated with 1000-ohm resistors. When the amplifier inputs were terminated with 1N32R crystal detectors, power supply noise was less than 2 db above amplifier noise, and therefore, more than 4 db below tangential signal level.

3. Conclusions

Tests on two production C5 units and one C6 unit show that this equipment meets engineering specifications in all except minor respects noted below.

(1) Separate gain adjustments are provided for the video and audio channels rather than a single control at the amplifier output as implied in the specifications. The range of each control is greater than the specified ± 10 db.

(2) Small departures from specified frequency-response characteristics, particularly at the upper end of the audio band and lower end of the video band, have little or no effect on system performance.

(3) Output response, at tangential level and for 0.25-microsecond input pulses, is 1 db outside the specified limit. However, the variation is not greater than the probable measurement error for those conditions.

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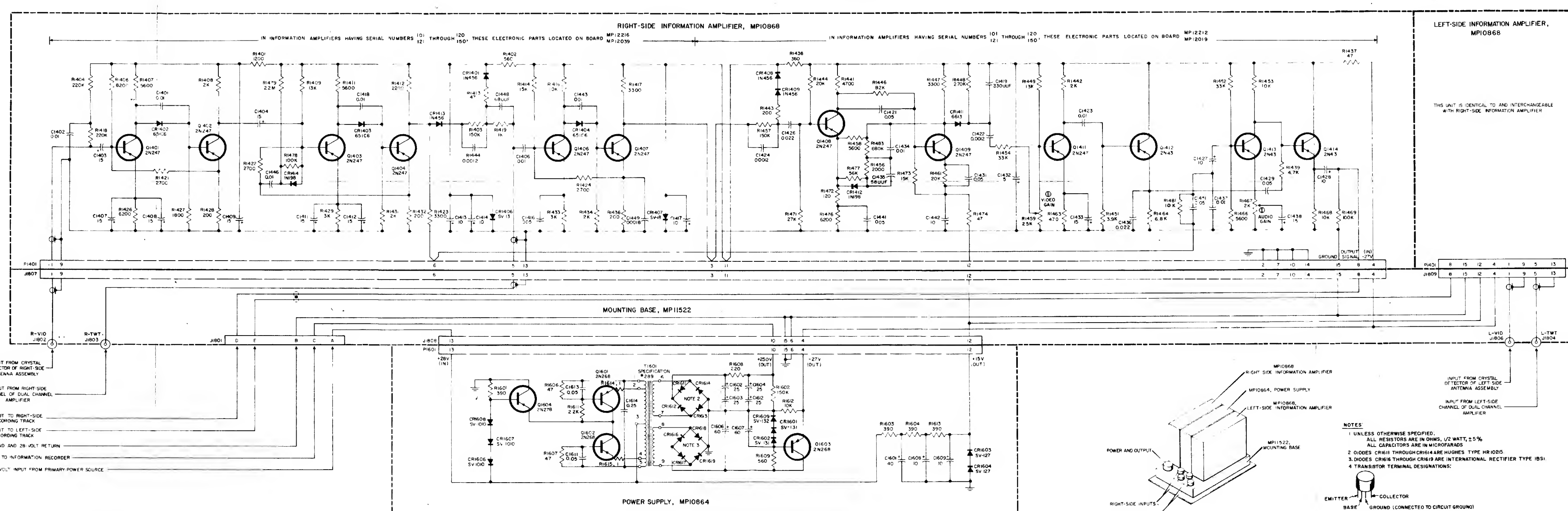

Figure 1. Modular Unit, Schematic Diagram

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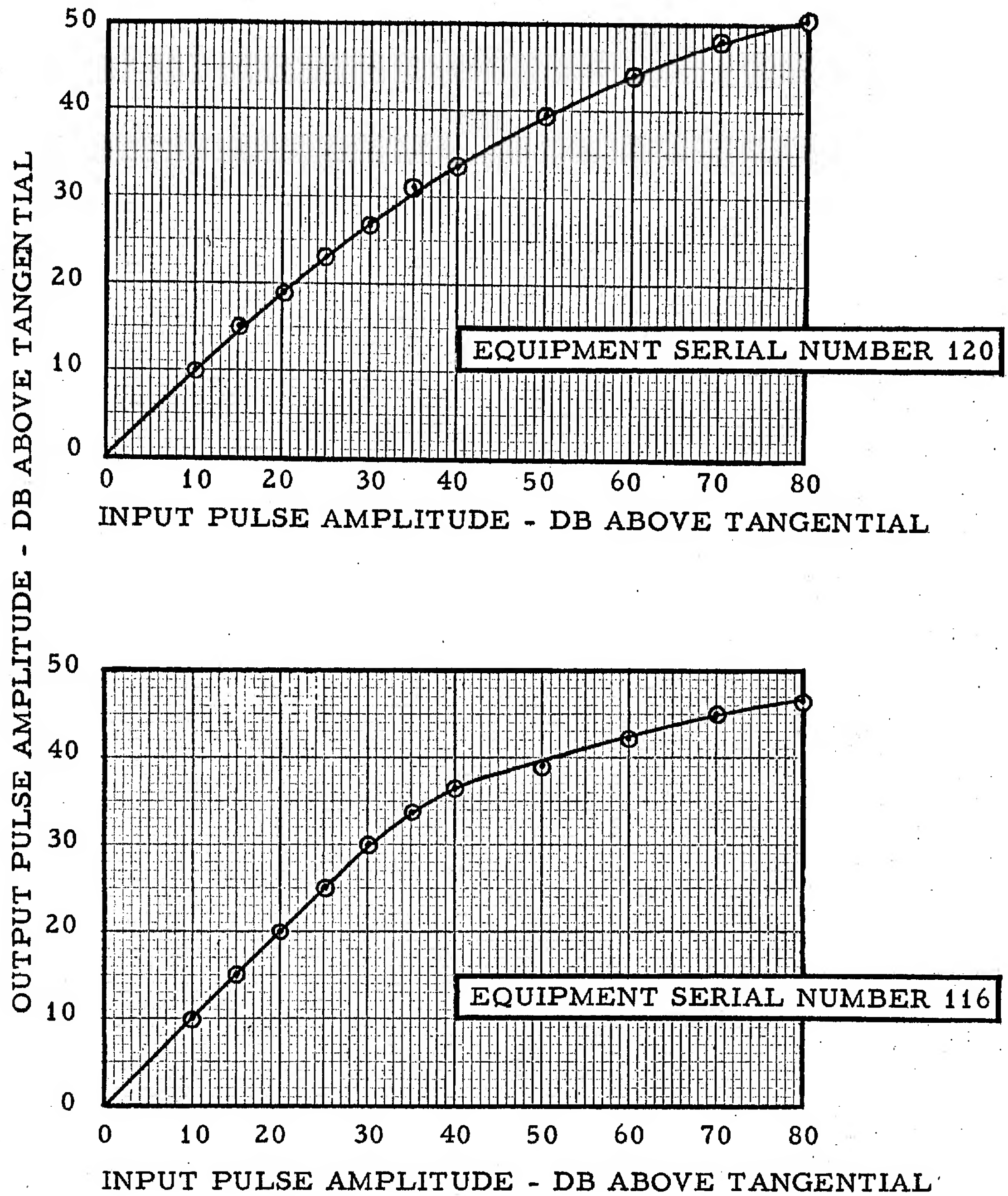


INPUT PULSE = 1 MICROSECOND AT
1 KC P.R.F.
VIDEO INSERTION GAIN = 60 DB
AUDIO INSERTION GAIN = 45 DB
TANGENTIAL SENSITIVITY = 4 μV

Figure 2. Output Pulse Amplitude vs Input Pulse Amplitude

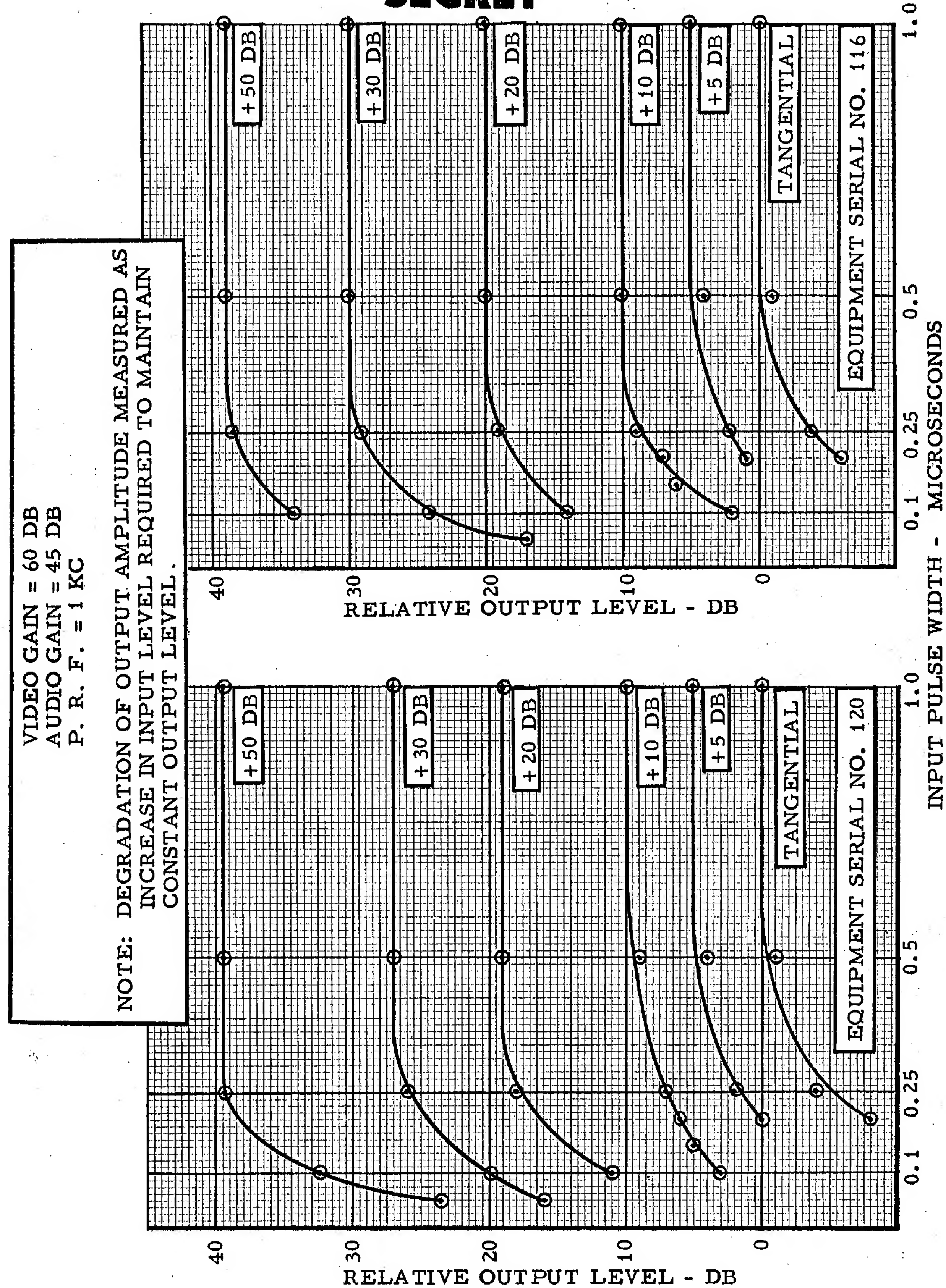


Figure 3. Output Pulse Amplitude vs Input Pulse Width as a Function of Input Pulse Amplitude (DB Above Tangential Level)

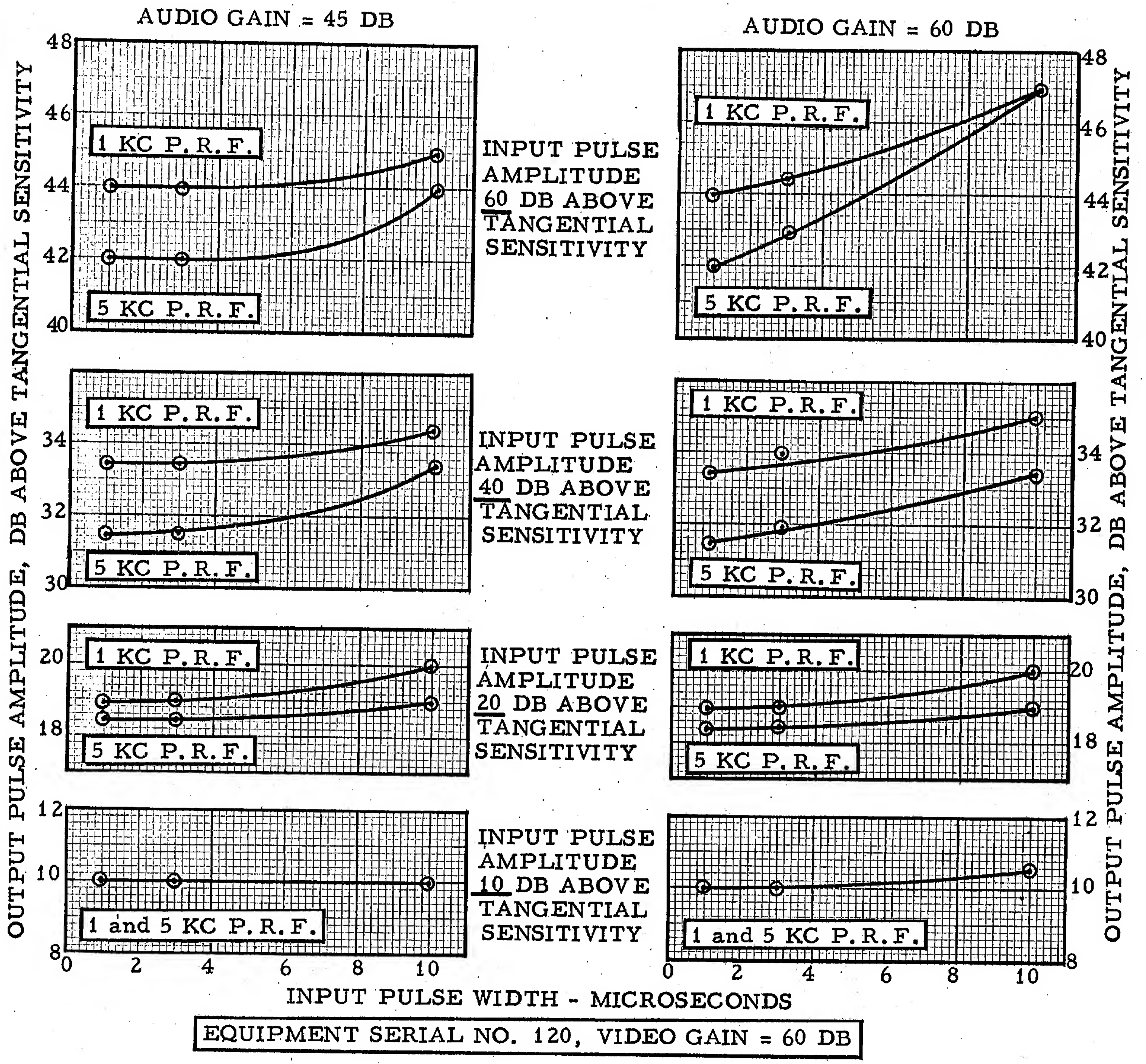


Figure 4. Output Pulse Amplitude vs Input Pulse Width as a Function of P.R.F. at Different Input Levels and Different Audio Gain Settings, Equipment Serial No. 120

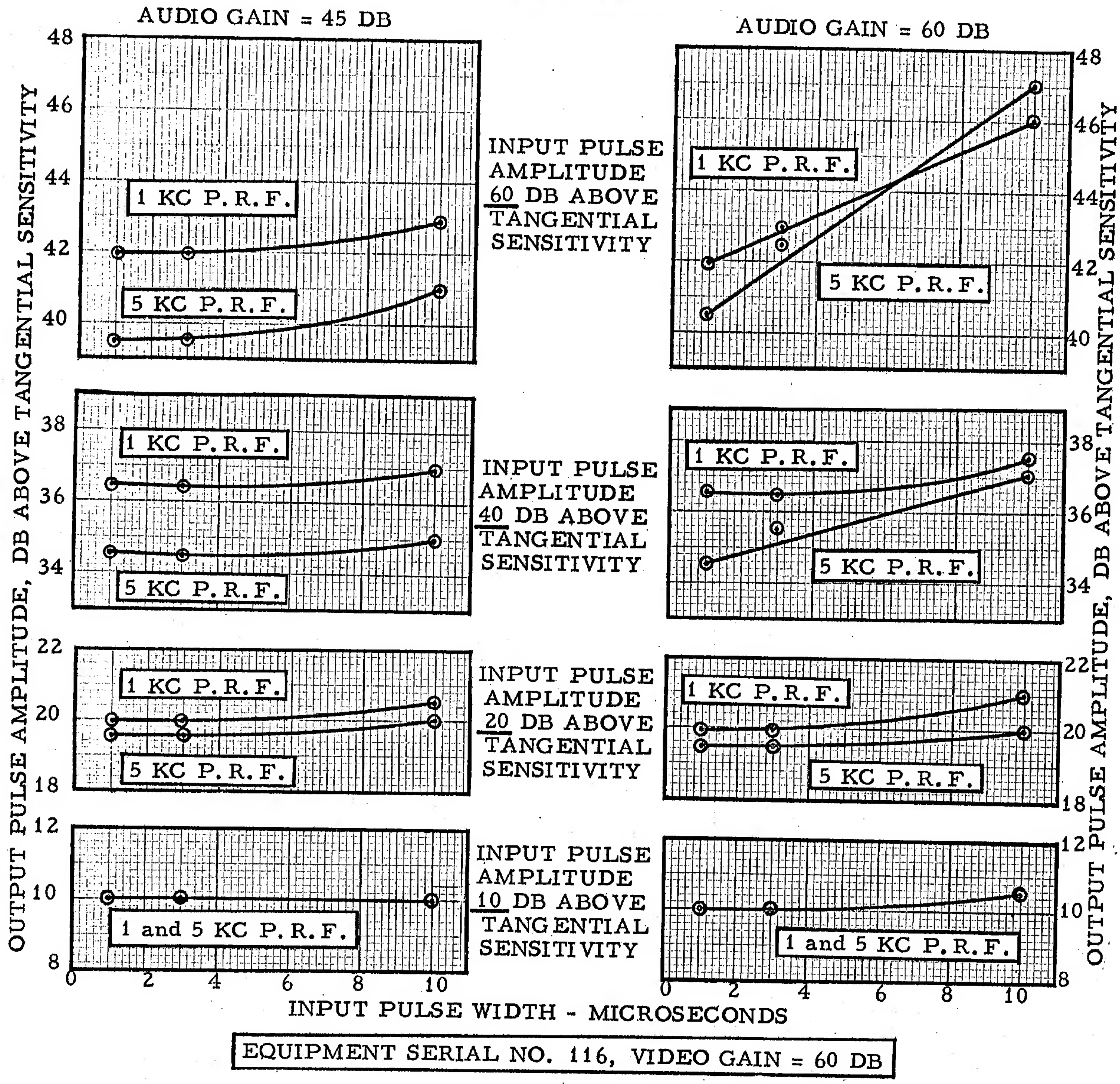
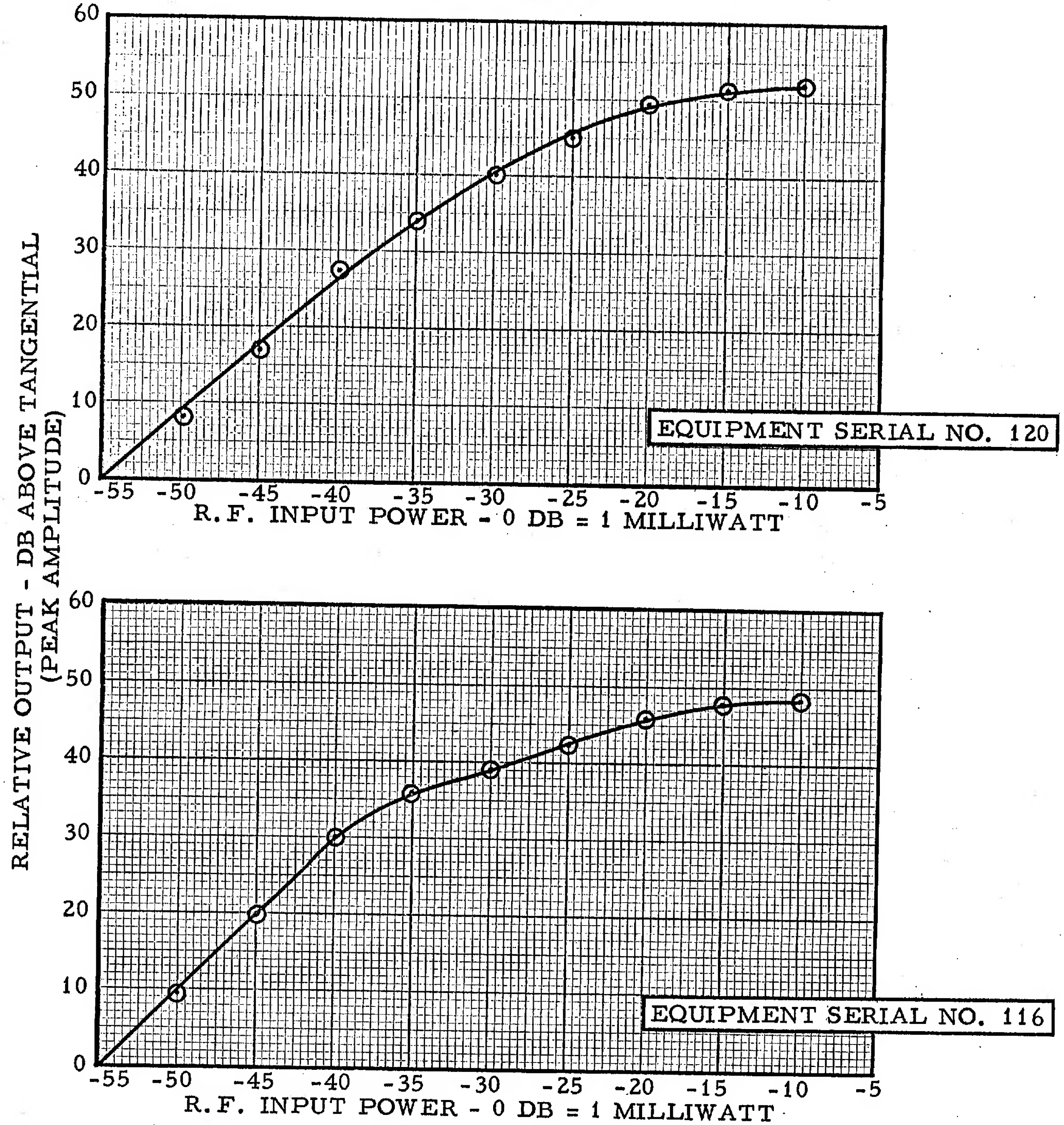


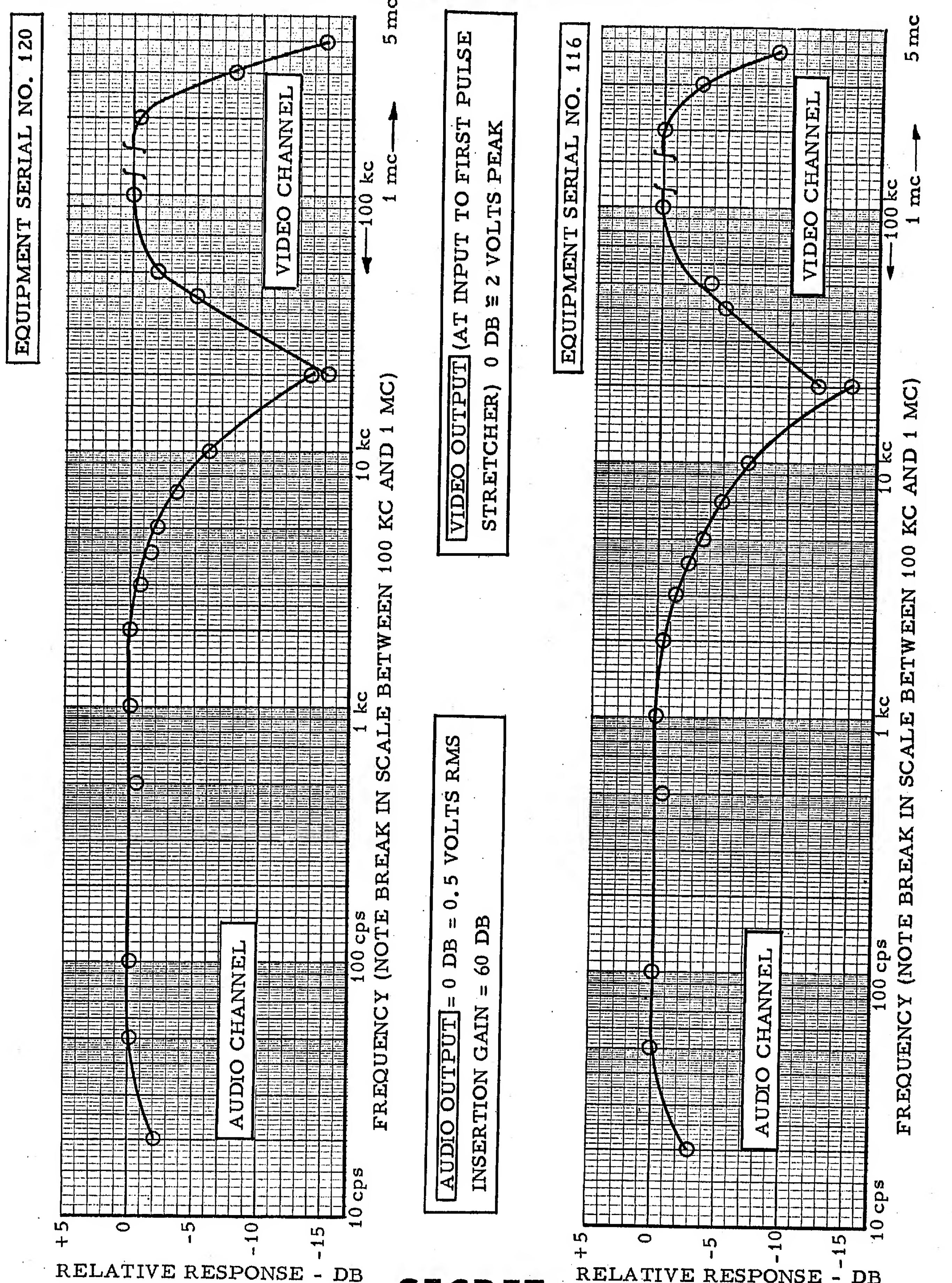
Figure 5. Output Pulse Amplitude vs Input Pulse Width as a Function of P.R.F. at Different Input Levels and Different Audio Gain Settings, Equipment Serial No. 116



1N32R CRYSTAL DETECTOR
CRYSTAL BIAS 20 μA
R.F. = 2000 MC
MOD. 1 MICROSECOND PULSE
1 KC P.R.F.
NORMAL VIDEO AND AUDIO GAIN

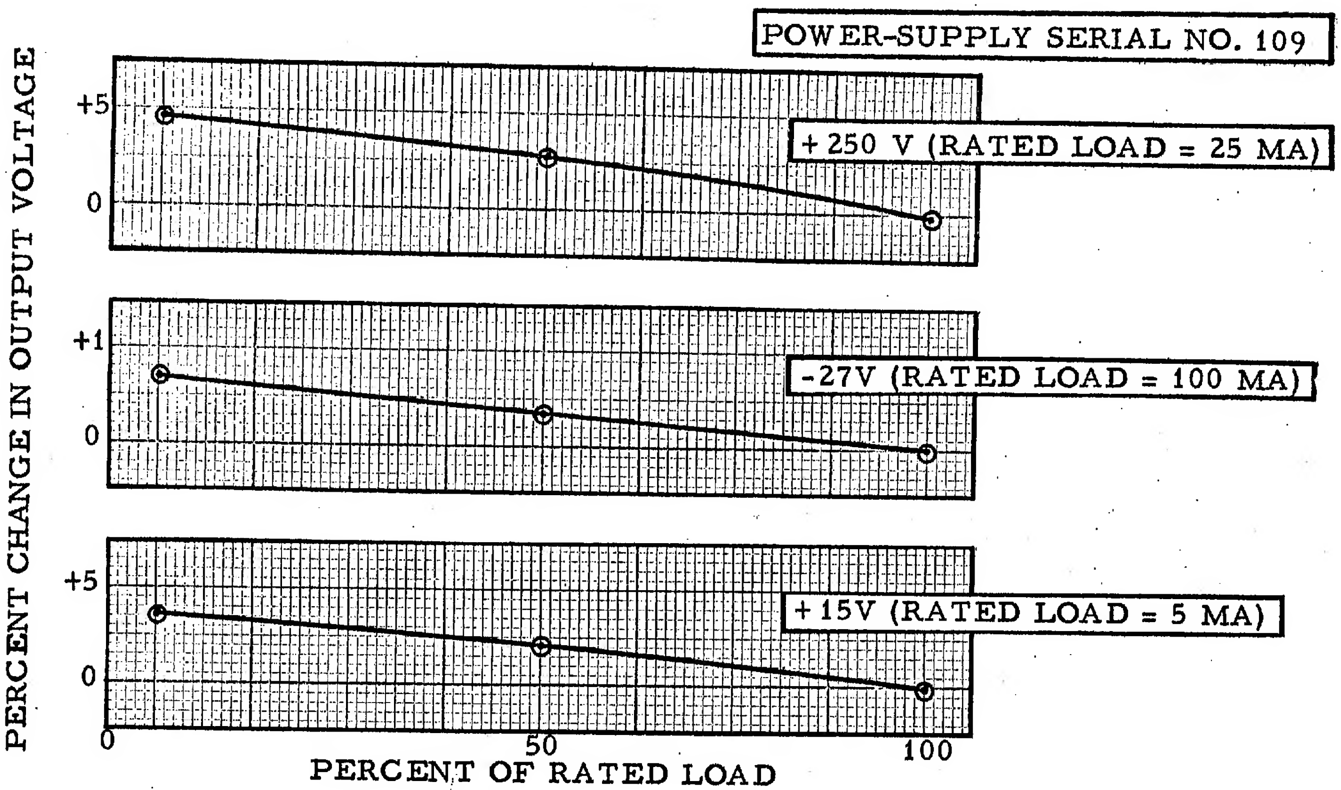
Figure 6. Output Pulse Amplitude vs R.F. Input Power

SECRET



SECRET

Figure 7. Frequency Response



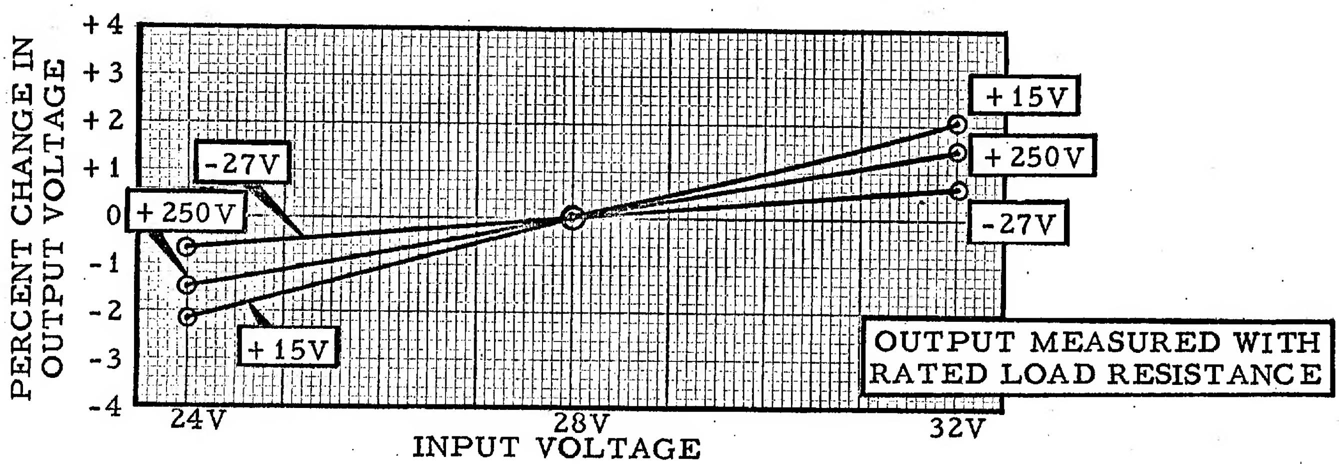
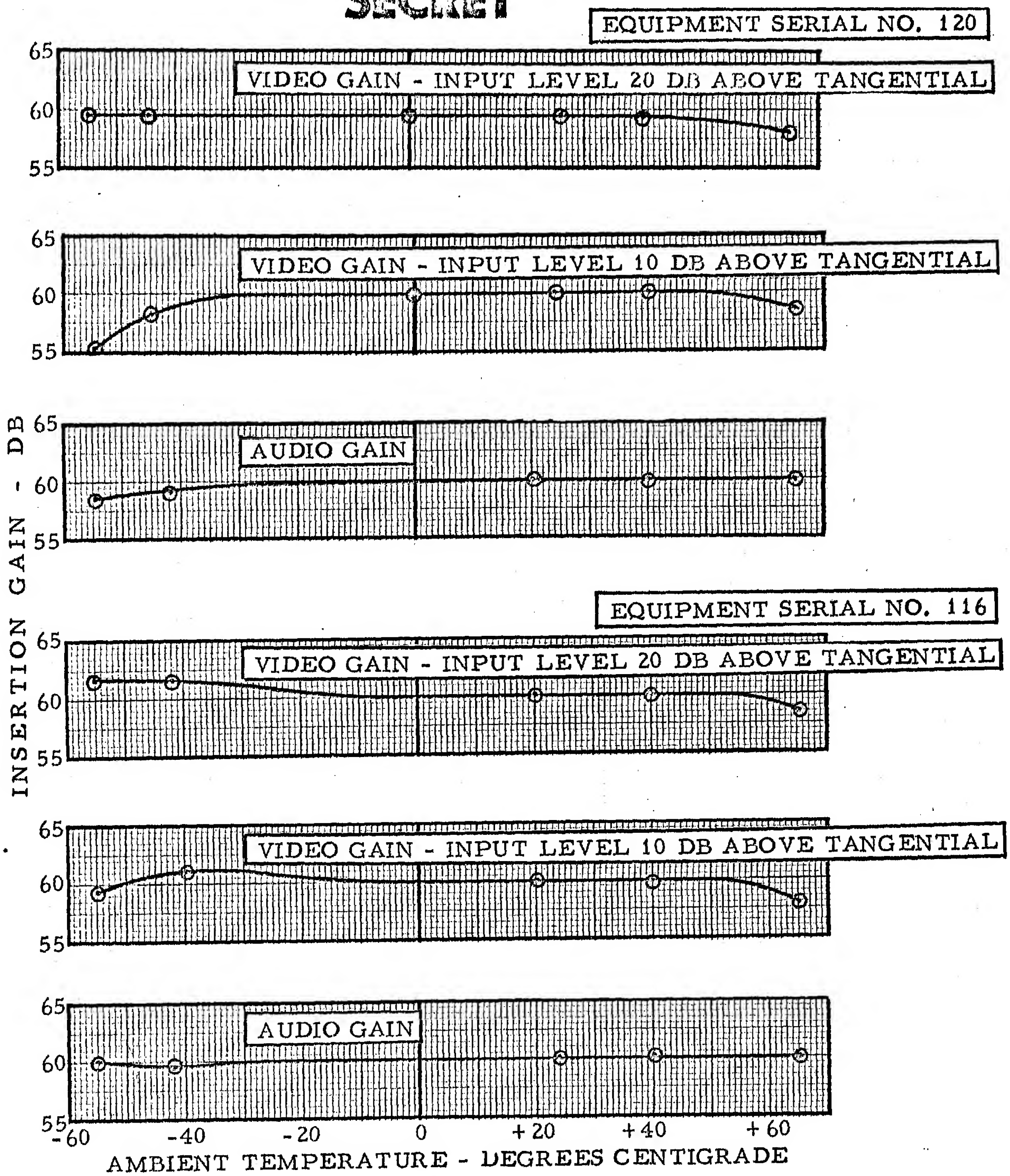


Figure 8. Power-Supply Regulation Characteristics vs Load and Input Voltage



NORMAL SETTING OF GAIN CONTROLS
1 MICROSECOND P. W. and 1 KC P. R. F.
1 KC AUDIO SIGNAL AT 1 V RMS OUTPUT LEVEL

Figure 9. Video and Audio Insertion Gain vs Ambient Temperature

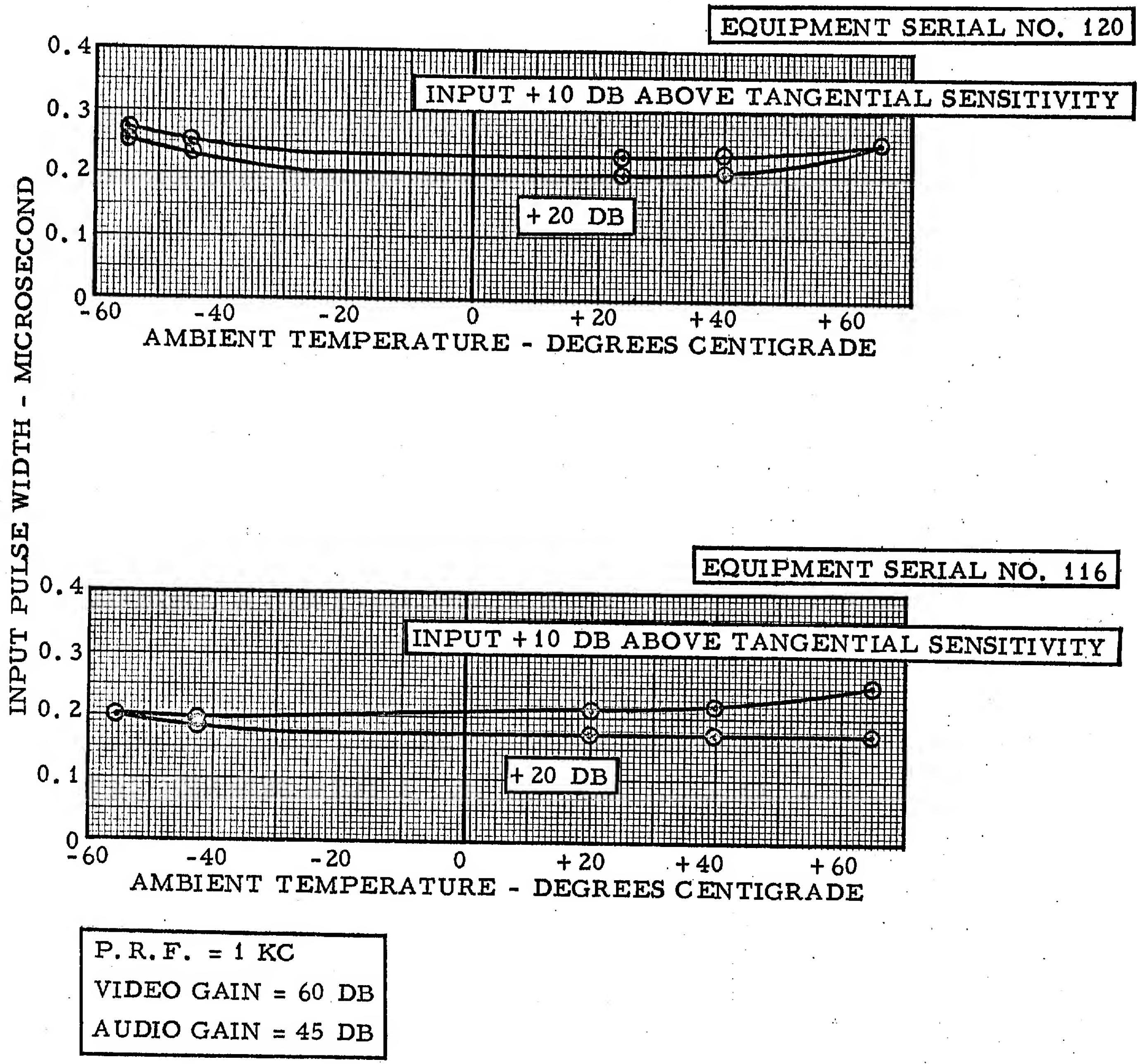
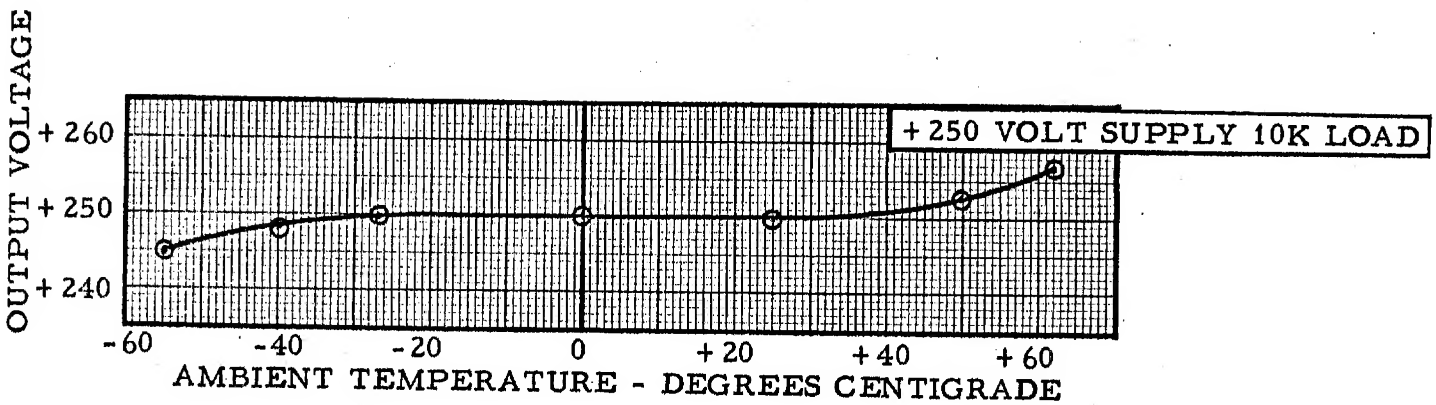
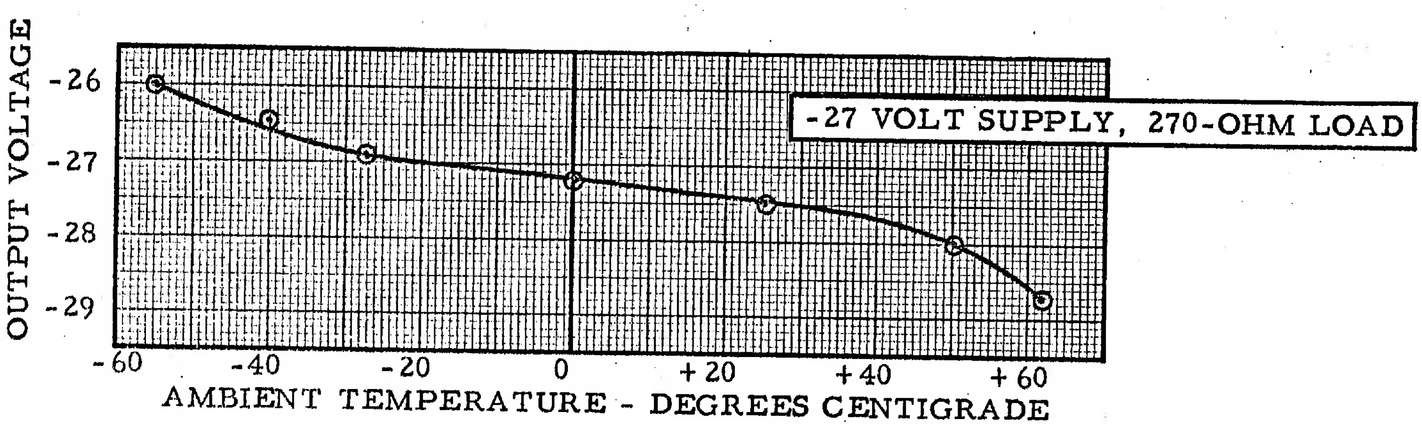


Figure 10. Input Pulse Width for Which Output is Down 3 DB (Referred to Output for 1-Microsecond Pulse) vs Ambient Temperature





EQUIPMENT SERIAL NO. 109

INPUT = 28 VOLTS

Figure 11. Power-Supply Output Voltage at Rated Load vs Ambient Temperature

APPENDIX A - TEST PROCEDURE C5 UNIT

Test Equipment Required

Tektronix 531 C. R. O. +53B Preamplifier
Hewlett-Packard 212A Pulse Generator
Power Supply +15v, 0.001A and -27v, 0.03A (C6 unit)
Hewlett-Packard 200CD Audio Oscillator
Hewlett-Packard 400D V. T. V. M.
Test Isolator and Attenuator (See Figure 1)
Test Attenuator (See Figure 2)

Test Procedure

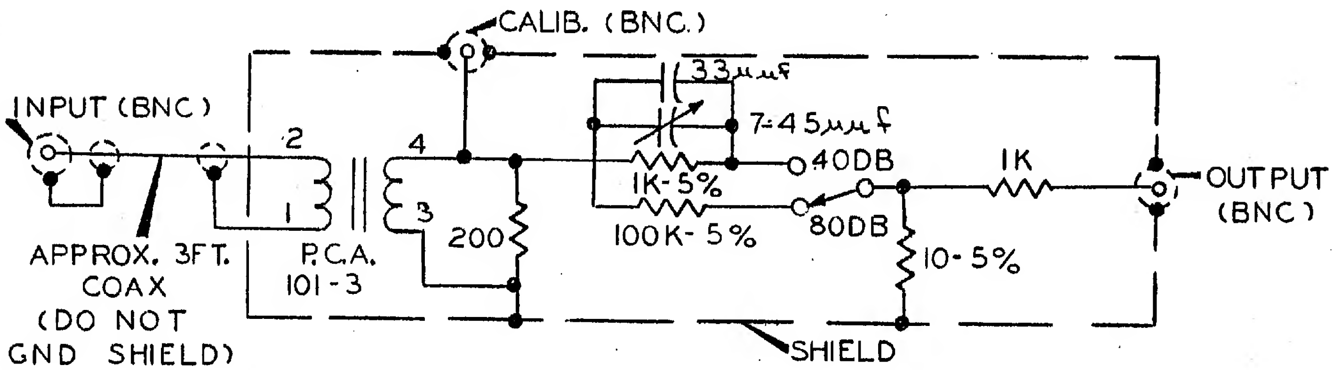


Figure 1. Test Isolator and Attenuator (40 and 80 db)

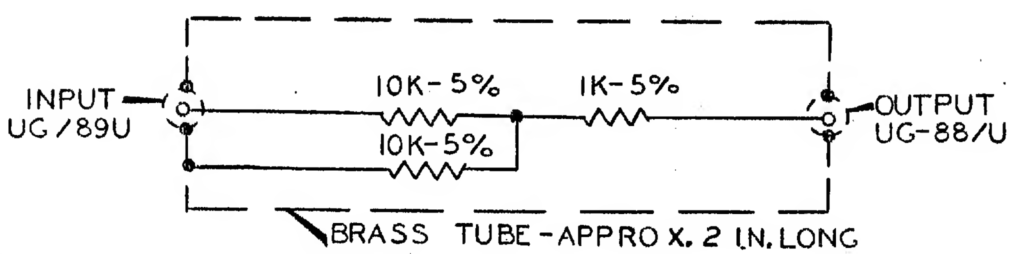


Figure 2. Test Attenuator (60 db)

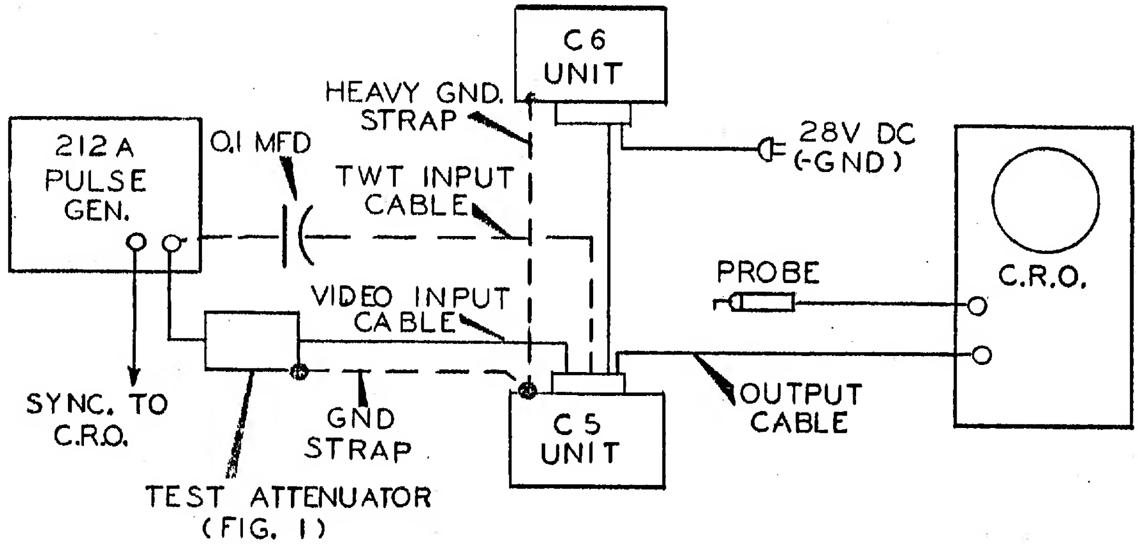


Figure 3. Video Test Set-Up

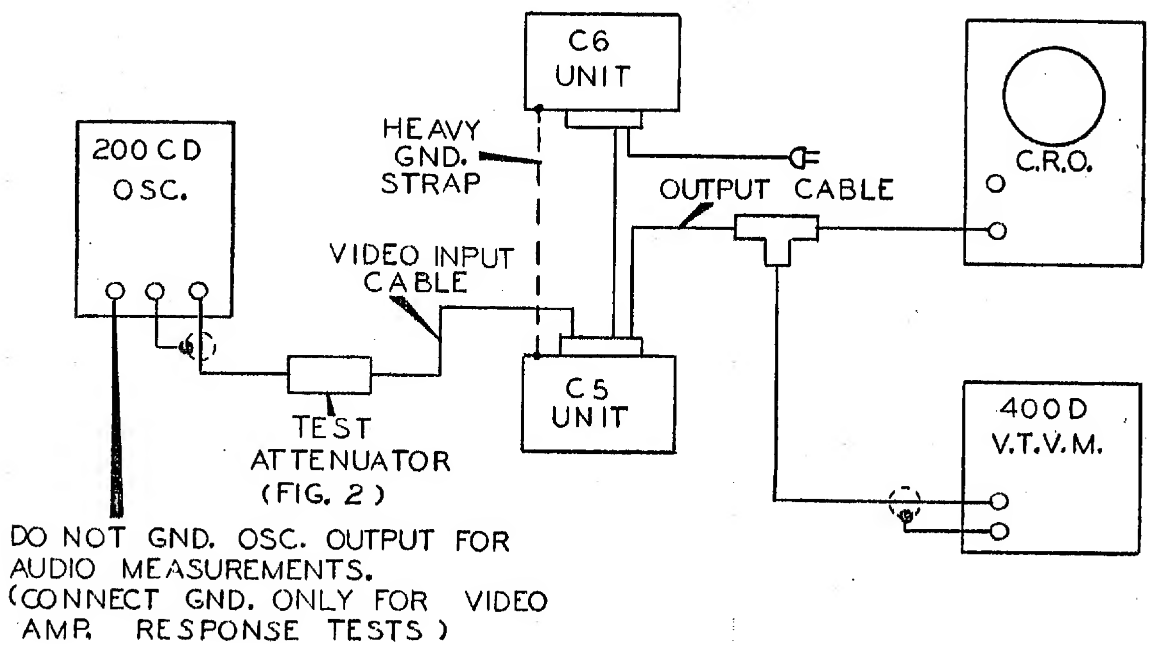


Figure 4. Audio Test Set-Up

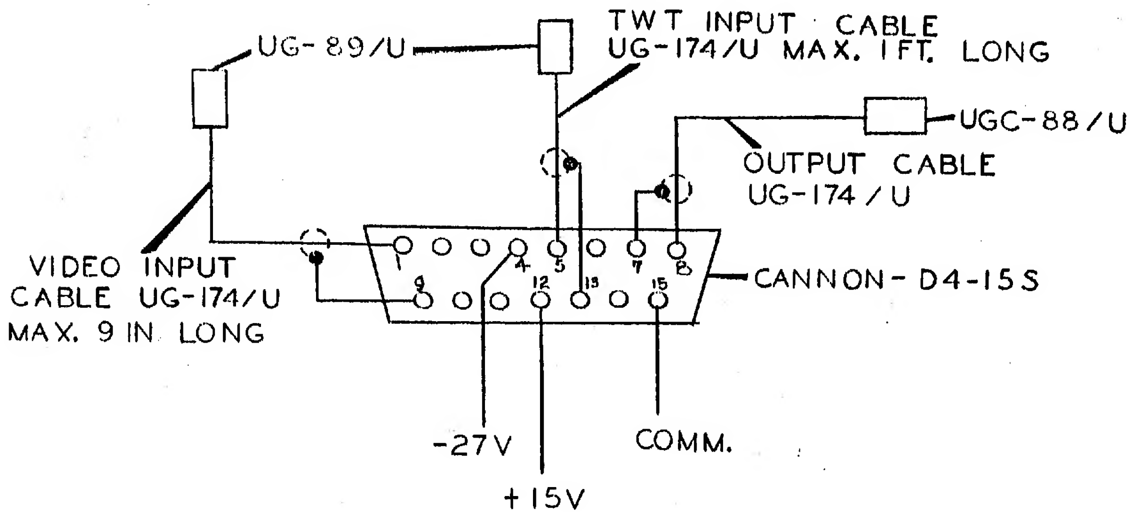


Figure 5. Test Cable

1. Pulse Performance Tests

Connect test set-up as shown in figure 3. Make certain that chassis of C5 and C6 units and case of test attenuator are grounded together. Case of pulse generator should not be connected to amplifier chassis ground.

Turn audio gain control (R67) to minimum.

a. Pulse Gain

(1) Connect C.R.O. probe to collector of Q7 (R17). Turn video gain control (R59) to maximum. Set test attenuator to 80 db and adjust output of pulse generator to produce signal of tangential level at collector of Q7 (see figure 6 below). Use 5-microsecond positive input pulses at 1 kc - p.r.f. Set C.R.O. to 5 microseconds/cm sweep speed.

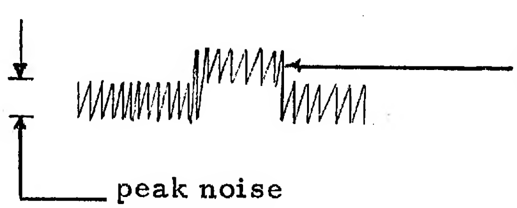


Figure 6. Tangential Sensitivity

Connect C.R.O. probe to input terminal of amplifier and increase signal level until pulse amplitude can be readily observed on C.R.O. (0.05V or greater). Calculate tangential sensitivity at input as the pulse amplitude observed on the C.R.O. less the increase in signal required to observe the pulse. Record tangential sensitivity in microvolts on test report.

e.g. After setting signal level to produce tangential signal at sixth stage, signal level is increased 80 db to provide pulse amplitude of 0.06v at input terminal:

Tangential Sensitivity = 0.06V/10,000 = 6 microvolts

(2) Set input signal at 10 db above tangential level and measure peak negative pulse amplitude at output of C5 unit. (Because of noise, the output pulse will not be sharply defined, and the amplitude should be measured as the average peak amplitude as judged by C.R.O. observation.) Use 100 microsecond/cm sweep speed.

Without changing attenuator setting, measure peak pulse amplitude at "CALIB" output of test attenuator. Calculate video gain in db as difference between input and output signals in db plus attenuator setting (80 db) and record value as "maximum video gain" on test report. Note: This measurement gives the value of insertion gain from a 1000-ohm source rather than the voltage gain from input-to-output terminals.

(3) With input signal set at 10 db above tangential level, adjust video gain control so that gain as measured in (2) above is 60 db. Record value as "video gain at factory setting" on test report.

(4) Connect TWT input cable to pulse generator output. Use 0.1 mfd blocking capacitor between pulse generator

and TWT input to provide dc isolation. With C.R.O. probe at collector of Q7 set pulse generator output to tangential level. Use additional 50-ohm coaxial attenuator between pulse generator and TWT input if necessary. Increase pulse-generator output 10 db and measure voltage gain from TWT input to output of C5 unit. Do not change setting of video gain control from (3) on page 4. Record TWT gain on test report.

b. Pulse Response

(1) Connect test set-up as in figure 3 with pulse generator and test attenuator connected to video input cable. Connect C.R.O. probe to collector of Q7. Set signal input at 20 db above tangential level with 5 microsecond positive pulses at 1 kc - p.r.f. Observe pulse rise time at collector of Q7 - 0.2 microsecond maximum.

(2) Set signal input at 10 db above tangential level and observe output of C5 unit on C.R.O. Decrease pulse width until level of output pulse has dropped 3 db from peak amplitude at 5-microsecond pulse width. Pulse width for 3 db drop should not be greater than 0.25 microsecond.

(3) Observe output pulse for signal input levels 20, 40, and 60 db above tangential. At each level setting the peak output amplitude should vary less than 1 db as pulse width is varied from 1 to 10 microseconds.

2. <u>Frequency Response Tests</u>

a. Audio Gain

(1) Connect test set-up as shown in figure 4. Set audio oscillator output to 0.5 volt r.m.s. at 1 kc. Measure insertion gain in db from oscillator output to output of C5 unit (including 60 db attenuator loss).

For example:

$$\text{Gain} = 20 \log_{10} \frac{V_{out}}{V_{in}} + 60 \text{ db},$$

at maximum and minimum settings of audio gain control. Record values on test report.

(2) Adjust audio gain control so that audio gain is the same as video gain established in 1a (3) on page 4. Record value as "Audio gain at factory setting" on test report.

b. Audio and Video Response

(1) With oscillator output and audio gain control set as above, record frequency response at output of C5 unit over the range 20 cps to 20 kc at the frequencies indicated on the test report. Zero db reference is the output at 1 kc. Frequency response should be flat within 2 db from 100 to 2000 cps and down not more than 3 db at 50 and 4000 cps and not less than 6 db at 10 kc.

(2) Connect C.R.O. probe to collector of Q9 (R47). Ground low side of oscillator output at oscillator terminals as indicated in figure 4. Set oscillator at 100 kc and adjust oscillator output so that undistorted low-level signal is observed at collector of Q9. Record frequency response at values indicated on test report using output at 100 kc as 0 db reference. Output should be down not more than 4 db at 50 kc and not less than 10 db at 20 kc.

3. Pulse Compression Characteristics

a. Nominal Characteristics

Connect test set-up as shown in figure 3. Leave video and audio gain controls at factory setting as obtained above. Set pulse generator output at 1 microsecond p.w. and 1 kc p.r.f. Measure peak output voltage of C5 unit as input

pulse amplitude is varied in 5 and 10 db steps above tangential level as indicated on test report. Record readings in db with output at tangential level as 0 db reference.

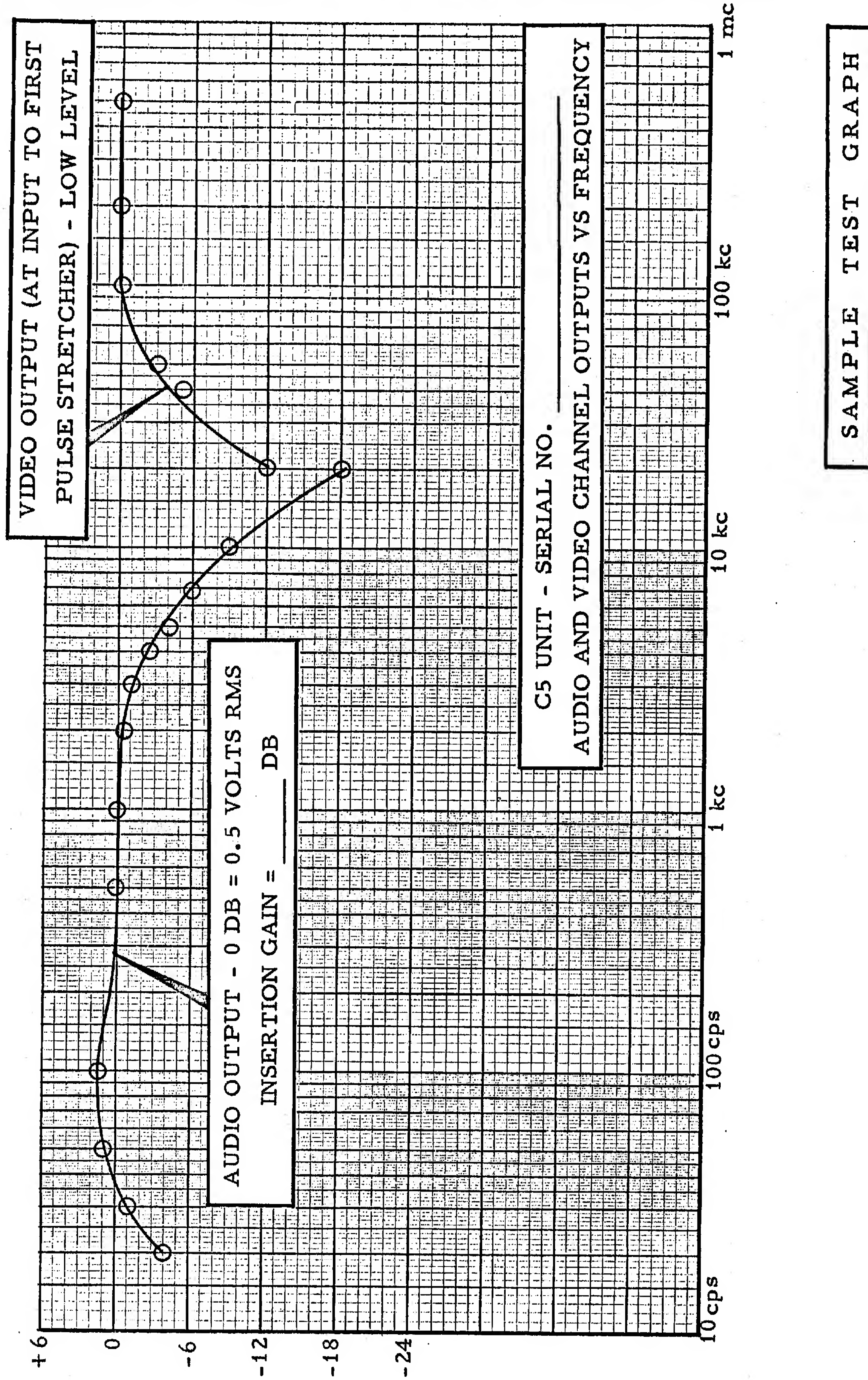
b. Variation of Pulse Width and Rate

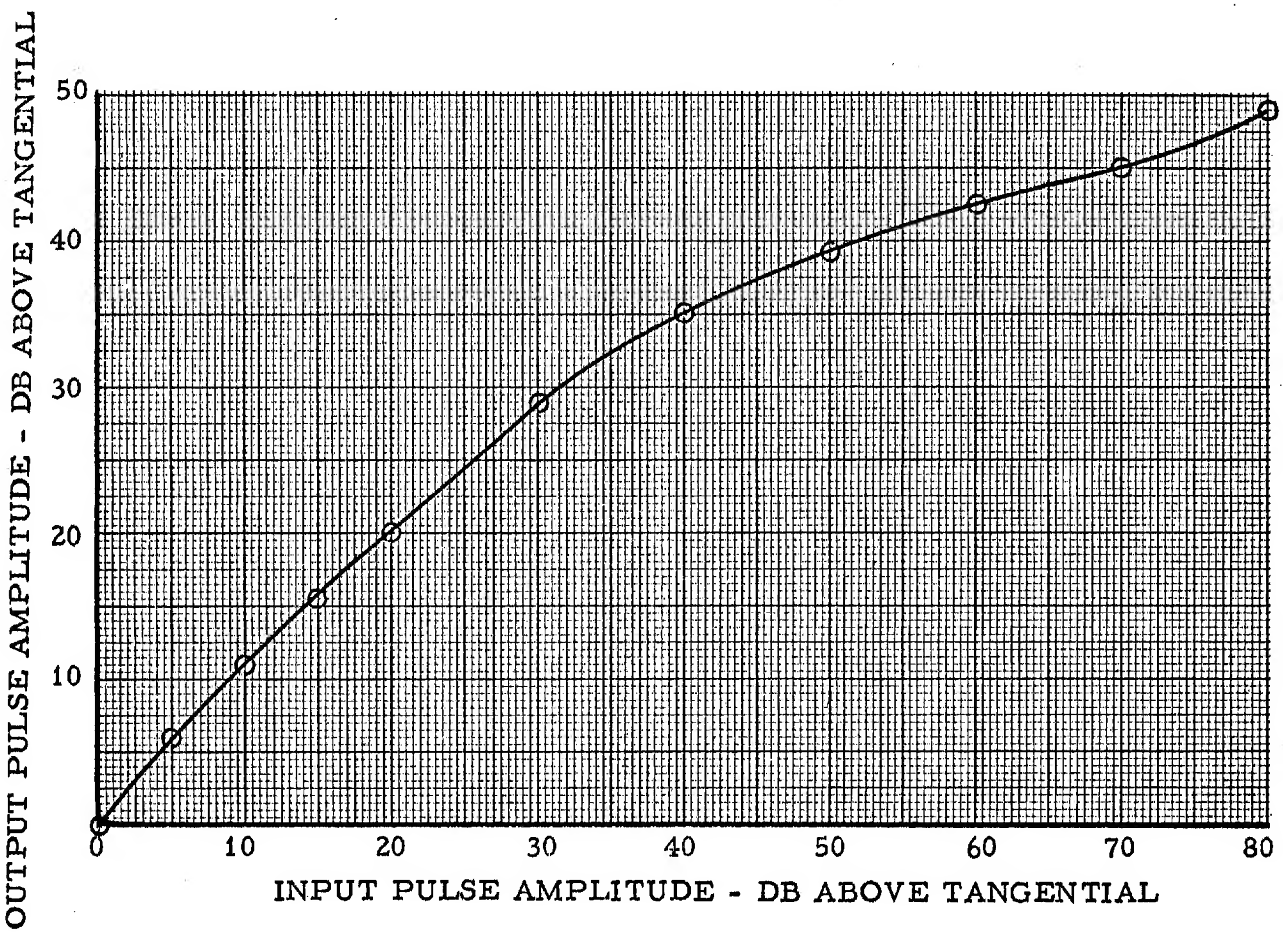
(1) Set pulse input amplitude at levels shown in test report and record pulse width at which output amplitude is down 3 db referred to amplitude at 1 microsecond p. w. and 1 kc p. r. f. for each level.

(2) Set pulse generator at 1 microsecond p. w. and record output amplitude for each of the input levels above for p. r. f. 's of 2, 3, and 5 kc.

4. Graphical Data

Prepare curves of pulse compression characteristics and audio and video frequency responses similar to sample curves attached.


SAMPLE TEST GRAPH
C5 UNIT - SERIAL NO. ____
AUDIO AND VIDEO CHANNEL OUTPUTS VS FREQUENCY
VIDEO OUTPUT (AT INPUT TO FIRST PULSE STRETCHER) - LOW LEVEL
AUDIO OUTPUT - 0 DB = 0.5 VOLTS RMS
INSERTION GAIN = ____ DB
+6
0
-6
-12
-18
-24
10 cps
100 cps
1 kc
10 kc
100 kc
1 mc



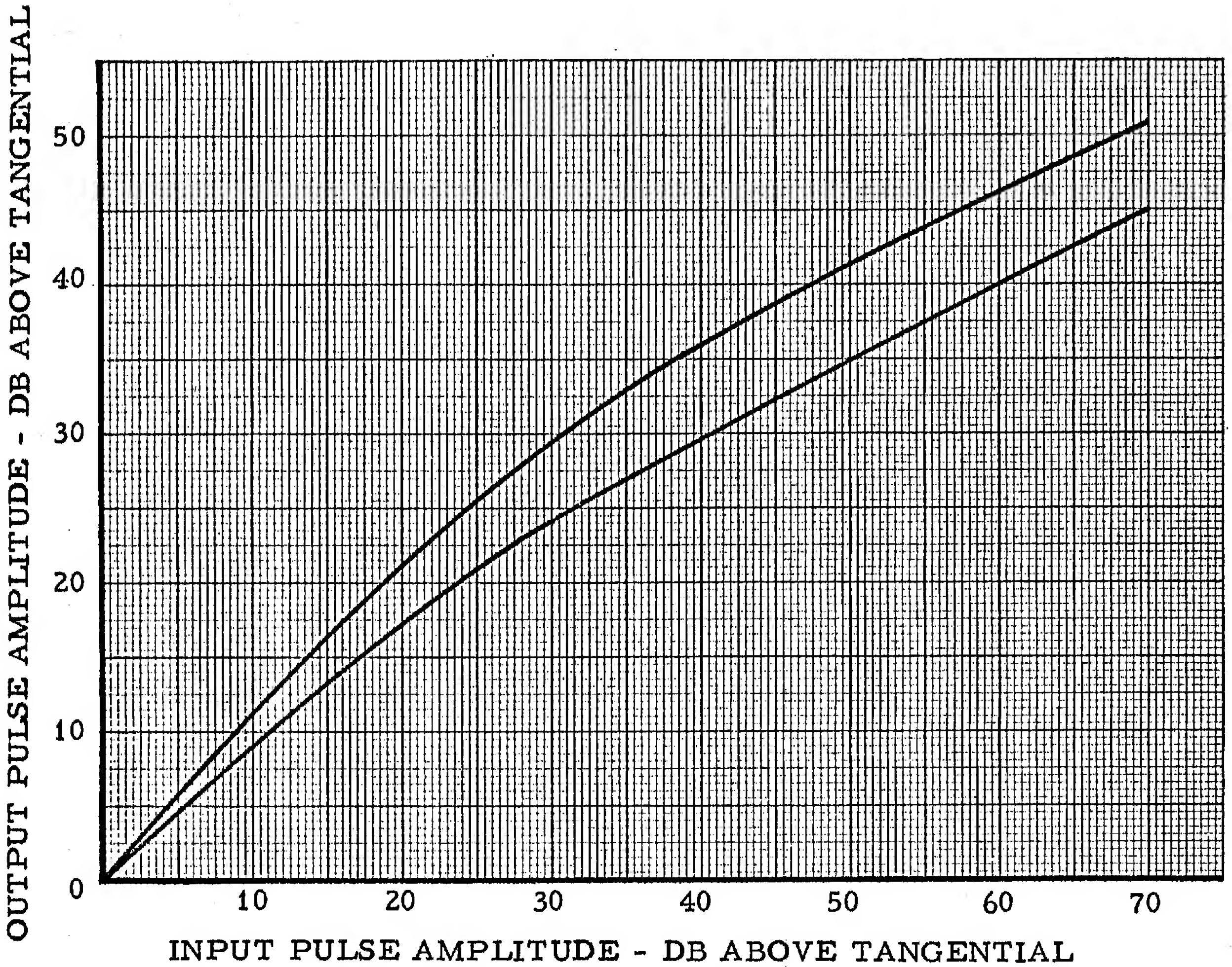
C5 UNIT SERIAL NO. ____________

PULSE INPUT VS OUTPUT AMPLITUDE

INPUT PULSE 1 MICROSECOND AT 1-KC P.R.F.

VIDEO AND AUDIO GAIN = ________ DB (INSERTION GAIN)

SAMPLE TEST GRAPH



C5 UNIT
LIMIT CURVES FOR PULSE COMPRESSION
CHARACTERISTICS. INPUT PULSE = 1 MICROSECOND
AT 1 KC P.R.F. VIDEO AND AUDIO INSERTION
GAIN = 60 DB

APPENDIX B - TEST PROCEDURE C6 UNIT

Test Equipment Required

Tektronix 531 C.R.O. with 53B Preamplifier
DC Voltmeter - 15, 30, and 250 volt ranges, 10,000 ohms/volt
or better -
Calibrated $\pm$ 2% at above voltages
DC Ammeter - 1A range, $\pm$5% accuracy
28 volt supply at 1A

Test Procedure

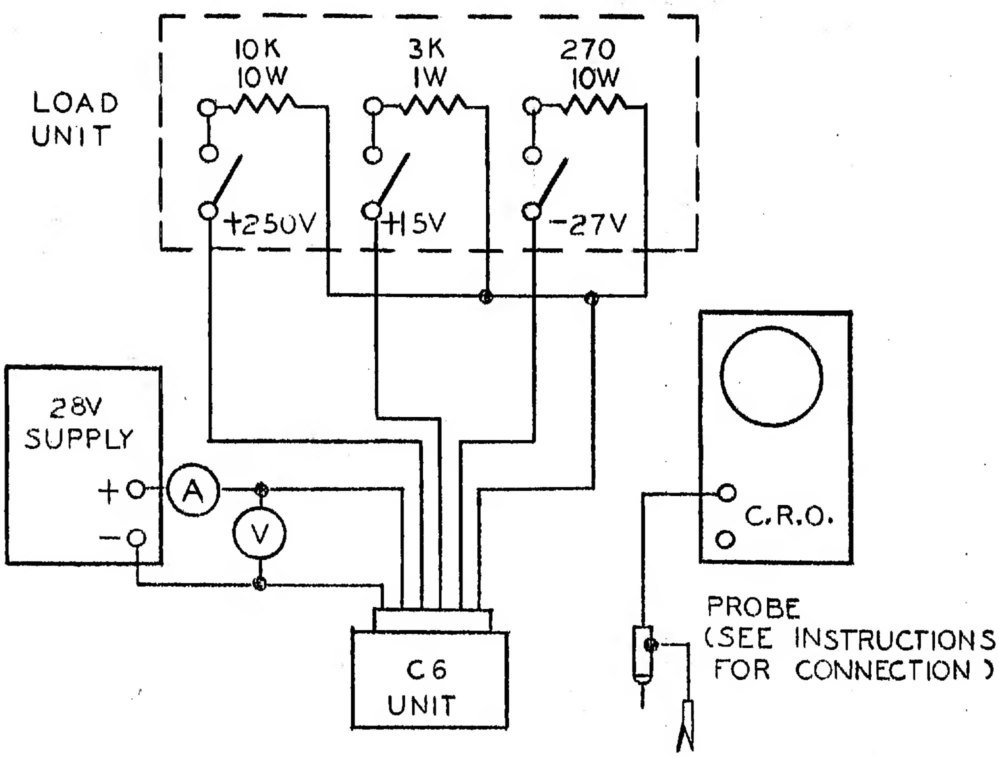


Figure 1. Power Supply Test Set-Up

1. Output Voltage Tests

Connect test set-up as shown in figure 1. Apply 28V dc to input, and measure voltages at output under full load (switches on load unit closed). Voltages shall be within the limits specified below.

-27V, ± 7% (-25.1 to -28.9V)
+15V, ± 7% (14 to 16V)
+250V, ± 5% (237.5 to 262.5V)

2. Voltage Regulation

a. Load Variation

At each output measure variation in voltage from full-load to no-load. Leave full load on outputs not under test. Regulation shall be within limits specified below.

-27V, ± 2% (0.54V maximum change)
+15V, ± 2% (0.30V maximum change)
+250V, ± 10% (25V maximum change)

b. Supply Variation

Vary input voltage from 24 to 32 volts. Output variation under full load shall be within the limits specified above.

3. Ripple Voltage

Connect C.R.O. probe to each output. Ground C.R.O. through clip-on probe to common side of power supply at the load resistor terminal for each measurement. Do not ground C.R.O. through any other load. Peak-to-peak ripple voltage shall be within limits specified below.

-27V, 0.05V p-p maximum
+15V, 0.05V p-p maximum
+250V, 0.10V p-p maximum

4. Miscellaneous

a. Starting

If not ascertained in previous tests, make sure that power supply oscillator circuit will start when 28V is applied with load resistors connected to outputs.

b. Current Requirement

The current supplied by the 28V dc source shall not be greater than 0.65A with full load on outputs.

c. Switching Time

Place C.R.O. probe on terminal #2 of the power transformer. Ground probe to case of power supply. 75% rise time of switching transient shall not be greater than 20 microseconds and not less than 5 microseconds.

APPENDIX C - TEST REPORT

C5 Amplifier Serial No. _______

1. (a) Maximum video gain _______ db
   (b) Maximum audio gain _______ db
   (c) Minimum audio gain _______ db
   (d) Video and audio gain at factory setting _______ db (low level)
   (e) TWT gain at factory setting _______ db (low level)

   Note: All gains above are insertion gain measured from 1000-ohm source to high impedance load (100K or greater).

2. Tangential Sensitivity _______ microvolts at input terminals.

3. Video input vs output characteristics, 1 microsecond input pulse, 1 kc p.r.f., audio gain at factory setting.

Input (db re tangential level)	Output Peak volts db
0	0
5	
10	
15	
20	
30	
40	
50	
60	
70	
80	

4. Video Frequency Response at Output of 8th stage

Frequency	Output - db
500 kc	0
200	
100	
70	
50	
40	
20 kc	

5. Audio Frequency Response at Output of Amplifier

Frequency	Output - db re 0.5V rms
20	
30	
50	
100	
500	
1 kc	0
2 kc	
3 kc	
4 kc	
5 kc	
7 kc	
10 kc	
20 kc	

6. Video Output vs Pulse Width and Repetition Frequency

Level (db tangential)	Pulse Width for 3 db loss μ sec.	Output vs p.r.f. (db re 1 kc output)		
		2 kc	3 kc	5 kc
10 db				
20				
40				
60				